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RESEARCH ARTICLE

Mobile Technologies: Undergraduate STEM Students' Perspectives about Webtools for Writing

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Abstract: Many students struggle with writing skills. The most recent National Assessment of Educational Progress-Writing (2017) concluded that only 25% of eighth- and twelfth-grade students could proficiently write a text. The results for students from diverse backgrounds were even lower. This has impacts on students as they move into post-secondary education and are expected to write more specific genres of texts such as lab reports. This study focused on lower-division university STEM students completing an online survey about their writing skills and how webtools could be a source to help them improve the content and quality of their writing during a 15-week semester. The results of the survey (n = 40) and follow-up interviews of students (n = 10) indicated that they have persistent challenges with writing such as organizing ideas and editing. With access to the writing webtools at mid-semester, students' lab report grades demonstrated improved content and quality scores in weeks 8-15. The authors also discuss limitations and ideas for future research.

Keywords: Writing Webtools, STEM, Mobile Technologies

1 Introduction

Writing is an essential skill in life. As a prime means of communication in the sciences (Drew et al., 2017), the meta-genre of informational writing often entails logic sentence sequencing, specific vocabulary, and high-level spelling, which can all be difficult for undergraduate students. To investigate students' experiences with informational writing, this study asked lower-division chemistry students to comment on their writing skills and how webtools (*e.g.*, short strategy videos, lab report writing websites) could help them better manage the writing of lab reports. With Science's technical vocabulary and argumentative genre, more students can experience challenges with managing text production.

1.1 How Writing can be Challenging

Writing is a complex task (Graham & Alves, 2021). One of the first steps to being a better writer is to read high-quality texts and analyze how they are written (Graham, 2020; Graham & Harris, 2017). Reviewing high-quality exemplars helps students see how ideas are formulated into a sequence (overall organization) along with the development of sentences, paragraphs, and a text's structure (beginning/middle/end) (Duncanson et al., 2020; Kim, 2020; Tai, 2017). This practice offers the writer the opportunity to see how ideas and vocabulary are managed into connected text to make complex and science-specific topics, for example, clear and concise content for a reader to understand. Reviewing strong examples can help students, but they also must learn to manage the sequence of completing their own finessed texts (*e.g.*, lab reports) with other strategies: idea generation, creating an outline of ideas, choosing words/vocabulary and managing spelling to make sentences, being cognizant of their text's structure (beginning, middle, and ending content), and making edits to produce a good final copy. Instructors should be aware of and understand that the writing process is not easily mastered by all students – especially more specialized genres such as lab reports (Behzadi & Gajdács, 2021; Graham, 2019). Students should be offered examples and strategies to help manage writing.

Researchers have suggested various approaches to the teaching of writing. Flower and Hayes (1980) cognitive-processing model focus on planning (idea generation, use of oral language), translation (drafting connected text), and reviewing (revising to produce a finessed final text).

Vygotsky (1980) suggested the practice of self-talk (a type of self-dialogue through the process of ideas and writing) as it can help students who struggle with writing manage a challenging task, such as idea generation. Dockrell and Arfé (2020) recommend four aspects to writing instruction: students should have the opportunity to frequently practice writing; awareness that writing represents personal meaning making (metacognition); offering systematic formative feedback to students; and providing high-quality examples for students to emulate in their own writing. Dockrell and Arfé emphasized the social aspect of writing, as well as the individual and developmental differences of struggling writers. Identifying the steps in the writing processes (*e.g.*, from idea generation to finessing a final text) helps to identify the needs in each part of the writing process and what challenges and strategies can be offered to help a student who struggles with writing.

As students are assigned a writing task, they will need to first choose their text's topic and approach. This can be challenging for many students (Cordeiro et al., 2020; Graham, 2020; Heong, 2013). Students may be reluctant writers, not be motivated to practice their writing skills, or have had low-performing experiences in the past. Students may have difficulties with executive functioning skills such as attention and memory to manage spelling, for example (Corgeiro et al., 2020). These experiences can contribute to feelings of not knowing where to start in a writing assignment. Once a student has chosen a topic, text needs to be drafted to define and describe each section of the text. These processes require a concurrent ability to sequence ideas, spell and choose words appropriately, create sentences into paragraphs, and manage the text's structure (beginning, middle, and end) (Graham et al., 2020). With a complete draft in hand, the writer then needs to review and finesse (make edits) to produce a high-quality final copy (Graham & Harris, 2019). This complex activity often poses challenges for students who struggle with writing due to a lack of experience in analyzing others' texts as well as practicing editing their own texts to improve.

When analyzing writing difficulties, instructors also need to be cognizant of how students may struggle with writing. The results of the U.S. National Assessment of Educational Progress for Writing (2017) indicated that 75% of students could not compose text at a basic level. Similar results were found for reading. Given the complex nature of writing and how being an avid reader can help, students benefit from learning strategies and practices that can help them improve writing.

1.2 What Strategies and Practices can Help

When a writer is having difficulty, strategy instruction (Graham et al., 2020) and technology tools (Strobl et al., 2019) are two prime means to attain improvement. Like being an avid reader, a struggling writer can review high-quality examples of the same genre as the writing assignment. The use of exemplars can provide students with a better understanding of the requirements of a written task, as well as the skills that need to be employed to complete it (Hawe et al, 2017). Analyzing these texts offers students a means to see how content is organized, and ideas are phrased within that genre. Once a first draft is completed, students can seek feedback from a peer, personnel at a writing center, or the instructor. Common ways to help students increase their writing skills include proofreading their own work, doing peer reviews, and correcting their primary drafts before they submit their final copy (Hyatt et al., 2017).

Students and instructors can also benefit from strategies that help a writer develop content for a text. Mnemonic strategies are good examples (Mastropieri & Scruggs, 2018). Plan, organize, and write (POW) helps a writer focus on developing key ideas and organizing them into a coherent sequence to help produce a good written draft. Instructors can also organize highly-capable writers as peer editors to help struggling writers improve their prose (Biagno & Salavory, 2021). Having a means to access strategies that students can view on-demand and outside of class would provide additional opportunities to learn and practice.

Web videos can be a beneficial means for an instructor to share writing strategy ideas with students. Discussing rubrics for a few minutes in class can help students better understand expectations. Providing infographics of graphic organizers and thinking maps can help students organize and plan thoughts in science writing (Lott & Read, 2015). An instructor-created web video and class discussion about high- *vs* low-quality texts can help. Students having specific examples can help promote their understanding of a writing task. The combined use of rubrics and exemplars can assist student writers throughout the writing process and support self-monitoring and self-regulation (Hawe et al, 2020).

With all the challenges writers face, there are many places and ways to get help with academic writing asynchronously when a teacher or the instructional format is not enough for an individual

student to be successful. This study investigated how webtools for lower-division chemistry students accessed asynchronously could help students manage lab report assignments. Students today use technology as an essential tool for learning and life. Offering writing webtools is a practical means to help students with writing.

1.3 Technology Tools for Writing

Technology is an ever-growing aspect of life and learning (Vogels et al., 2022), and writing has always been linked with technology. Sound writing instruction and integrates technology and recognizes the potential benefits of writing tools to support student writing (CCCC Position Statement, 2015). Many computer-based software programs (*e.g.*, Microsoft WORD, Google Docs) have integrated spell and grammar checks. These software programs have developed into more online-option types of applications. Microsoft WORD is more accessible within a browser and Microsoft Editor has now been added with more elaborate editing and user-help features. Grammarly is very popular amongst computer uses as a browser-based editor. Screen readers have become a basic part of most types of devices so that the user can voice their ideas and the computer manages the typing. The mix of ideas and voice commands has prompted the development of even more sophisticated options for writers.

Artificial intelligence (AI) applications such as ChatGPT are now available for users to type a question or idea and then receive one or more narrative responses as options (Korzynski et al., 2023). A student could ask Google for some best recipe ideas for a lasagna dinner resulting in a few or more listed options; with asking AI, the app could analyze the most popular recipes and (re)configure a set of ingredients and directions as being representative of the best aspects from Google's recipes list. This analytical power of AI to quickly search, analyze and produce a result can prompt people to pose questions about its ethical use (*e.g.*, Farrokhnia et al., 2023). Tate et al. (2024) completed an analysis of ChatGPT's scoring historical argumentative essays (n = 493) of students, mainly Latino, in Southern California-area high schools. After the research team had human scorers trained in scoring the texts independently using a 1-6 scale, texts that had score differences between raters greater than one point were assessed by a third rater. Later, after each text was submitted to ChatGPT for scoring, no statistical differences were found between the ratings of the human versus AI scoring. While AI offers an efficient means to assess students' writing, the authors cautioned that this be used for low-stakes tasks (*e.g.*, classroom practice writing) and not for official reporting such as semester grades.

There are concerns about the powers of AI and how its abilities may evolve in the future (Marr, 2023). Many academics fear that AI will render a new level of plagiarism and lack of student-generated ideas and text for assignments (McIlwraith et al., 2023). While valid, these concerns may be less of an issue for a genre such as STEM lab report writing where the text is based on the student's lab work and specific class's topic, reading(s) and terminology. Students benefit from having webtools that offer strategies and examples specific to scientific/lab report writing so that they have the skills to critically analyze the online content they find and consider.

Webtools (*e.g.*, short videos and infographics about writing strategies, make varied sentences, high-quality exemplars of lab reports) are a means to help students manage specific aspects of writing (Minor, 2021). Manidaki and Zafiri (2021) explored sixth-grade students' (n = 16) use of educational technology and Web 2.0 tools for writing in a Greek primary school. The results indicated that students liked and benefited from using the writing webtools; students (68%) felt that their learning and applying the tools was facilitated given the small group work tasks of Project Based Learning (Bell, 2010; Van Lam, 2011). Webtools can better address the nature of writing expository texts such as lab reports as they require idea generation, organizing ideas, crafting sentences and paragraphs, and then making edits – all based on a course's text(s), readings, class notes, and lab experiments. Webtools such as short videos about how to manage an introduction, body, and conclusion of a lab report can help a student piece together the student's experiences, readings, and class notes to draft a lab report. Webtools that offer ideas of how to make varied sentences (*e.g.*, adjectives, adverbs, subordinate clauses) as well as weblinks to high-quality exemplars of how lab reports on other topics are organized and written would further help students manage their own writing.

1.4 Research Questions

This study sought to explore students' perspective about writing in the context of a lower-division university chemistry classes and to investigate how a set of online webtools could help students manage planning and composing texts. The research questions included the following: What were participants' perspectives about writing via an online survey and follow-

up interviews? Did participants' pre/post writing content and quality improve with use of WRITE following students having access to the webtools?

2 Materials and Methods

The authors employed a convergent parallel mixed methods design (Kroll & Neri, 2009; Taskakkori et al., 2020). During the first seven weeks of the semester, the instructor emailed the students an invitation to be part of this study by completing the online consent form, which then directed each participant to the online and anonymous survey questions; once students clicked submit, they were directed to the opt in/out webpage to indicate if they would be willing to do a 1:1 interview at a later time via Zoom. The online survey included likert-scale questions to generate quantitative data about students' writing experiences such as challenges and successes. Figure 1 provides a description of the sequential components of the study, which were done with parallel mixed methods: qualitative and quantitative components were conducted separately (in parallel) followed by a meta-inference (analysis) process to integrate the results (Taskakkori et al., 2020, p. 392).

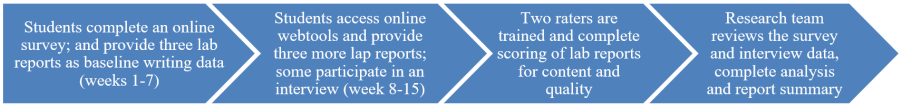

Figure 1 Study Design's Data Collection and Analysis Phases

With this data, the authors completed descriptive statistics, correlational analysis and binary logistic regression (Coolidge, 2020; Hahs-Vaughn & Lomax, 2020; Pampel, 2020). The follow-up 1:1 interviews provided qualitative data on students' perspectives about writing and what they believed would help them improve. The data obtained from the survey and interviews provided the authors with a means to make comparisons (interpretation phase) about students' perspectives on writing and how the webtools could help them.

2.1 Setting

The study was completed with students at a Carnegie/research-extensive university campus located in the western United States. The campus is part of a larger university system that offers undergraduate, master's, and doctoral degrees in many domain areas including science, engineering, and math as well as courses with a technology focus. Of the nearly 3,000 students at the campus, the gender distribution was about 50% female and 50% male. The average age was 25. More than 40% were first-generation college students.

At the beginning of week 8, students learned in their lower-division chemistry class that writing webtool links (see Table 1) had been placed in their course's learning management system (*e.g.*, Canvas). The authors chose webtools to help students manage writing components of a lab report: aim, methods, results, and conclusions of a scientific experiment. The authors included existing online tools as well as the authors' instructor-created videos as helpful writing resources and strategies.

Table 1 Writing Webtools

Tool	Writing Resource
Short video	Highly-Effective Habits of Good Writers
Short video	Sentence Combining Ideas
Short video	Instructor's Discussion of Low/High-quality Exemplars
Short video	Instructor's Discussion of the Writing Assignment's Rubric
Website	Grammarly
Website	Purdue Writing Lab
Website	Ereading Worksheets

Examples of these tools included a short video of the instructor discussing the writing assignment's rubric, features of a low- and high-quality exemplar, and a suggested set of practices that good writers do, such as reading daily and reviewing and analyzing the kinds of texts that the student is expected to write. Students could access these webtools one or more times whenever it was convenient to them.

2.2 Participants

The research team included a chemistry class instructor and a lab instructor. Their students were the invited participants for this study. A total of 40 lower-division undergraduate students

agreed to participate. Their age range was 19-25 (mean = 22.32; SD = 1.67). Participants' gender was 45% male and 55% female. The distributions of participants' race/ethnicity were: 70% White/Caucasian, 10% Black/African American , 10% Asian, and 10% multiracial.

The student participants' chemistry course was Principles of Chemistry I (3 credits) and included topics about atomic and molecular structure, states of matter, quantitative relationships, thermodynamics, quantum mechanics, periodicity, bonding. It was recommended that students had previously completed one year of rigorous high school chemistry or a previous chemistry course. The chemistry lab reports' description to students is described in Table 2.

Table 2 Lab Reports Assignment Description

Subtitle	Content
Purpose	The purpose of the lab report is to document and communicate the findings and results of your experiment. In doing so, use the organizational structure outlined below. Each section should be clearly separated with their individual headings. Every section should start with an introductory sentence. The main content of the section should be in paragraph form. The text should be double spaced 11 or 12pt Times New Roman. There are resources to help and guide writing reports posted on Canvas.
Introduction	An introduction to the experiment should include the purpose (goals or objectives). What are you going to do, and what principles are to be explored? Connect a key objective or concept to the real world through a peer reviewed journal paper. Cite the journal paper using APA format for the intext citation and include its full reference in the reference section. When you are done with the lab, the Conclusions section will be written to address whether you achieved your goals, so it is important to state them here.
Materials and Methods	This section includes a brief description of the procedures, activities and the materials/ equipment used. In text citation should look like this: (Rice et al. 2016). DO NOT give bulleted lists, the section needs to be written in paragraph form.
Results	For this section, report only the facts/ data on observations (color, odor, heat, time, etc.) You can add tables and figures to the text with lesser important data, but the key results need to be stated clearly. This is important to show that you understand what is important! Each table and figure should follow the text that explained and referenced them within the section.
Data analysis / Calculations	This section demonstrates how you manipulated the data - applying equations, formulas, and statistics. It must be done in paragraph form with all equations/ calculations typed and embedded within the text then referenced *e.g.* (equation 1). A descriptive sentence or two should be included for each equation/ calculation that explains the math and or the chemistry.
Discussion	This is a very important section; it should demonstrate your understanding of the results and calculations and what they mean. This section should include supported opinions or thoughts that explain each of the key results and what they collectively mean. A very brief discussion about where errors could have come from, is often useful, but should only be a sentence of two and at the end of the section.
Conclusion	The conclusion should include a succinct summary of what was accomplished, including the key learning goals and specific findings.
References	Use APA style to list your lab manual and the peer reviewed journal paper reference used in the introduction. Ask a librarian, your lab instructor or internet sites such as Perdue OWL https://owl.english.purdue.edu/owl/resource/560/02/ for help with intext citations and https://owl.english.purdue.edu/owl/resource/560/05/ for help with reference section formatting. We recommend using the WSU Library Database system but you might find Google Scholar very helpful as well. Please note: Most books including text books are not peer reviewed literature, ask if you are unsure of what qualifies as peer reviewed literature. Post-Lab Questions: Paraphrase each question with its number and then provide its answer, clearly separating the two. Frequently, you will have already addressed the matter in the report, in such cases simply give the specific location where it can be found (*e.g.* See methods section.) Referring to your lab notebook pages is unacceptable.

The course's lab instructor introduced the lab report writing tasks to students, managed their work in the lab, and received students' lab report texts as uploaded documents in the course's

website. In week 8 of the semester, two members of the research team visited the students in class to introduce the project's survey and follow-up interview opportunities (with gift card incentives) as well as the online webtool weblinks page. The instructor then forwarded this information to students via email. The students who participated in the 1:1 interviews (n = 10) are listed in Table 3.

Table 3 Interview Participants

Pseudonym Name	Gender	Major/Degree	Race/Ethnicity	Year
Kirk	Male	Mech Eng	Caucasian	Sophomore
Taran	Male	Elec Eng	Asian	Freshman
Olivia	Female	Gen Biology	Caucasian	Freshman
Kate	Female	Biology	Caucasian	Sophomore
Bo	Male	Environmental Science	Caucasian	Sophomore
Kirk	Male	Biology	Caucasian	Junior
Diane	Female	Environmental Science	White	Junior
Tom	Male	Biology	Caucasian	Junior
Karen	Female	Biology	Latino	Junior
Grace	Female	Biology	White	Sophomore

2.3 Procedures for Data Analysis

2.3.1 Quantitative Data

The online survey (Table 4) data was summarized by calculating frequency totals or likert questions' mean scores in Microsoft Excel. This data provided a description of the participant sample's demographics as well as perspectives about writing.

Table 4 Survey Questions

Question	Option
1. Do you like writing?	Likert choices: like a great deal, moderate amount, little, neither like nor dislike, dislike a little, moderate amount, dislike a great deal
2. Do you voluntarily seek and read academic texts similar to your writing assignments to see what published writers do?	30 minutes, an hour, two hours, three hours, four hours, five or more hours
3. What is your experience with the following aspects of writing? a. Focusing attention in class to understand the content. b. Having the writing assignment explained in class (*e.g.*, provided written description, rubric). c. Attaining answers to questions about the writing assignment. d. Reading the required assigned text(s) before writing an assignment. e. Finding source texts to reference in my own writing. f. Planning and organizing my ideas. g. Spelling words and creating sentences. h. Making a first draft. i. Reading my own writing. j. Knowing what edits to make. k. Attaining feedback (*e.g.*, a peer, writing center on campus) when I seek it. l. Attaining a good grade on my writing assignments (*e.g.*, B or higher).	Never (have difficulty), Sometimes (have difficulty), Often (have difficulty), A lot (of difficulty)
4. Was writing difficult for you in school?	Not at all difficult, Somewhat difficult, often difficult, neutral, very difficult
5. Was reading was difficult for you in public school?	Not at all difficult, Somewhat difficult, often difficult, neutral, very difficult
6. Demographic questions (gender, age as of week 1 of the study, race/ethnicity)	

To have a holistic understanding of the change in participants' (n = 40) writing performance, the first author and two independent raters, each who had graduated with a bachelor of science

degree, created a lab report rubric. This rubric defined writing content and quality to include grammar, vocabulary, syntax, public understanding, and organization flow. Each subcategory of writing quality included five scales (*i.e.*, highest quality, high quality, average, below average, and poor quality) with the corresponding scores arranged in descending order (*i.e.*, from 5 to 1). Students' writing content was also evaluated according to seven areas: introduction, materials and methods, results, calculations, discussion, conclusion, and references. In a similar way, the subcategories of the writing content were organized into 5 scales from the highest to poor quality, with each subcategory corresponding to the score from 5 to 1.

The first author and the other two raters scored select example lab reports individually and then discussed how to attain a higher level of agreement. By the end of this training session, 90% of independent agreement was achieved. The two raters first scored each lab report independently and met with the first author to discuss disagreement to attain 100% agreement.

In the authors' summative analyses of students' writing, the mean scores on writing content and writing quality before and after the intervention were calculated. Specifically, the mean quality score increased from 3.7 in the pre-intervention phase to 3.9 after the intervention was completed. The content average score increased from 3.5 (*i.e.*, the pre-intervention average score) to 3.6 upon the intervention's completion. There was an increase of 0.1 in the total average score from the pre- to post- intervention phases. In addition, the lowest scores and highest scores in the pre-and post-intervention phases were compared. Although there was no change in the highest score, the lowest score noticeably increased from 1.6 to 2.5, which could be attributed, in part, to the implementation of the writing webtools intervention.

2.3.2 Qualitative Data

A few weeks after students began completing the survey in week 8, the first author began emailing students who had indicated their being willing to do a 1:1 interview. The first author arranged a mutually agreeable time, with each student who was willing, to meet via Zoom and discuss their perspectives about writing, the writing webtools offered in this study, and what could be added to the website to help them more. Each interview was audio recorded with transcription; these texts were used by the research team for later analysis to make themes and subthemes, and to choose illustrative quotes. The interviews (n = 10) ranged in time from 20-30 minutes with a mean of 22 minutes.

For data analysis, the authors used five-step framework analysis approach by (Hruschka et al., 2004; Ritchie & Spencer, 1994; Rubin & Rubin, 1995; Silverman, 2000). Thematic analysis included five steps. First, we read all of the transcripts multiple times to become familiar with the content, noted key ideas, and created initial categories (familiarization with the data). Second, we coded key themes and concepts from each page into categories as well as overarching subthemes (coding to identifying a thematic framework) (see Table 5).

Table 5 Example Coding of Interview Data

Coding Labels	Sample Quotes	Notes and Ideas
Idea generation, text production, revising and editing	"Creating a draft, reviewing and editing and then following that up with a final draft has been a little bit more difficult." (Bo)	Writing is a complex process.
Content knowledge. Applying information from class. Processing time	"There's just so much going on with the experiments that I'm not sure if we are provided with enough time to ask follow-up questions. The instructor begins the class with saying that students will have five minutes at the end to ask questions and to start working on your calculations for your lab report. It's just kind rushed." (Karen).	Learning the course content is needed to be able to integrate it into writing a lab report.

Third, after we created the codes, we reviewed our notes while cross-checking back to the research questions so that the codes helped to capture the participants' ideas (indexing). Fourth, we made a summary of the data into a matrix for each theme (charting). Fifth, we reviewed the matrix to make interpretations from the data to develop themes and explanations of interviewees' comments and ideas (mapping and interpretation). This iterative process provided for an in-depth review of the data and the resulting themes and subthemes.

2.4 Ethics Statement

This study was completed with human subjects approval: Helping Students improve their Writing Skills.

3 Results

3.1 Quantitative Results

The quantitative data for this study was comprised of two components. Students completed an online survey about writing during weeks 1-7 (see Table 6). Students' lab reports were analyzed for content (*i.e.*, did the students' text include the applicable information required) and quality (*i.e.*, overall composition, organization, flow of the text, etc.) to determine any differences in content and quality from lab reports submitted in weeks 1-7 versus those submitted after the start of access to the webtools in weeks 8-15.

Table 6 Student (n = 40) Survey Result Ratings about Aspects of Writing

Aspects of Writing[a]	**Mean**
Students focusing attention in class to understand the content.	2.27
Having the writing assignment explained in class (*e.g.*, provided written description, rubric).	1.99
Students attaining answers to questions about the writing assignment.	1.89
Students reading the required assigned text(s) before writing an assignment.	2.10
Students finding source texts to reference in students' own writing.	2.46
Students planning and organizing their ideas.	2.21
Students spelling words and creating sentences.	1.71
Making a first draft.	1.74
Students reading their own writing.	2.18
Students knowing what edits to make.	2.29
Attaining feedback (*e.g.*, a peer, writing center on campus) when I seek it.	2.01
Attaining a good grade on my writing assignments (*e.g.*, B or higher).	1.97

Note: The range for all rated answers was 1-4. [a] Likert Scale (Never [1], Sometimes [2], Often [3], A lot of Difficulty [4])

3.2 Statistical Analysis

Through correlation analysis (Hahs-Vaughn & Lomax, 2020), we found the following six variables have a significant impact on writing grades: 1) whether students can focus attention in class to understand the content, 2) whether students can quickly receive replies to their questions regarding the writing assignments, 3) whether students are good at spelling and creating sentences, 4) whether students know how to edit, 5) whether students can quickly obtain feedback on their writing, and 6) whether students perceived writing as an easy task during their high school years. Although these variables may have an impact on a student's grade for a written assignment, it was not significant. However, the findings offer possible insights to understand the impact of the covariates on improving writing grades, as suggested by previous research (Wasserstein et al., 2019). From this study, the extent to which students can focus attention on instructional content (the associated number is 9.8 per unit increase), the likelihood to attain feedback when they seek it (the associated number is 7.23) could considerably influence writing grades. Students' ability to edit (3.96) may also have a large impact.

To understand the bivariate relationship between the independent variables and students' belief in attaining a writing grade of B or higher, we assessed the Pearson correlations using a total of 40 lower-division undergraduate students agreed to participate in the study – completing the initial survey. Effect sizes were calculated with 95% confidence intervals. Six of the variables among those investigated in the survey had strong positive correlations with students' belief that they could attain a B grade or higher in their writing assignments. These variables included students' capability of focusing attention in class to understand the content ($r = 0.46$, $p = 0.003$), easiness of attaining answers to their questions about the writing assignment ($r = 0.42$, $p = 0.007$), easiness with spelling words and creating sentences ($r = 0.36$, $p = 0.022$), knowing what edits to make ($r = 0.52$, $p < 0.001$), the chances of attaining feedback from peers, instructors, or writing centers ($r = 0.45$, $p = 0.003$), and self-perceived difficulties in writing during high school years ($r = 0.42$, $p = 0.007$).

Binary logistic regression was then conducted to determine whether attaining a good grade in a writing assignment (having difficulty *vs.* never having difficulty) could be predicted from these six predictor variables (Pampel, 2020). Good model fit was evidenced by statistically significant results on an omnibus test of model coefficient, χ^2 (6, 40) = 24.73, $p < 0.001$, and large effect size indices when interpreted using Cohen (1988) (Cox and Snell $R^2 = 0.46$, Nagelkerke $R^2 = 0.64$), indicating that between 46% and 64 % of the variance in the dependent variable, whether students have difficulty or not in attaining good writing grades, can be explained by our independent variables.

Furthermore, we received a nonsignificant value of the Hosmer-Lemeshow test, χ^2 (8, 40) = 7.90, p = 0.44, which nicely supports a good fit of our model. The results suggest that the predictors, as a set, reliably distinguished between college students who have difficulty in obtaining a good grade in writing versus never having difficulty. With the data in our analysis, we had a very high percentage accuracy in classification (PAC) of 0.90, which indicates that 90% of the time when we make the predictions, we will be correct. It shows that our model has very good predictive capabilities.

In terms of the relationships between the independent variables and the binary dependent variable, all the predictor variables along with their categories were not statistically significant, which suggests that the odds for having difficulty in obtaining higher writing grades (relative to never having difficulty) are similar regardless of students' performance in focusing attention to understand the content, attaining answers to their questions about the assignments, spelling words and creating sentences, knowing what edits to make, attaining feedback, and having difficulties in writing in public schools. Even though the results are not significant, likely due to sample size, they can still convey meaning for us to understand the impact of the covariates on improving writing grades (Wasserstein et al., 2019).

Specifically, we can consider that the odds of gaining a good grade are increased by a factor of 9.8 by focusing attention on class to understand the course content. The odds that a student who can attain answers to their questions about the assignment will obtain a good grade in a writing assignment are 1.14. The odds that a student who can easily spell words and create sentences will receive a good grade are 2.39. If a student knows what edits to make, the odds for the student to have a high grade are 3.96. The odds of achieving a high score for writing are increased by a factor of 7.23 by being able to attain feedback when they seek it. Lastly, for every one-unit increase in the difficulties in writing a student encountered in high school, the odds of being difficult in earning a good writing grade increase by 2.4.

Overall, the logistic regression model accurately predicted 90% of the college students in our sample, with students who have difficulty in attaining good writing grades more likely to be classified correctly (96.3% of students having difficulty in earning good writing grades and 76.9% of students never having such difficulties correctly classified). The covariates, although yielding nonsignificant results, can still provide meaningful information for us to understand how they can predict students' writing performance in writing their lab reports.

3.3 Pre- and Post-Intervention Comparison

In addition to analysis of course grades and survey questions, we also conducted analysis of students' lab report writing (Coolidge, 2020). Students completed three lab reports in weeks 1-7 of the semester. In week 8, they were offered access to the writing webtools, which they could apply to their next three lab report assignments in weeks 8-15. Results from this scoring are listed in the Table 7. Students improved in content and quality after having access to the webtools in week eight.

Table 7 Students' Pre/Post Content and Quality Scores

	Content	Quality
Before	3.50	3.79
After	3.59	3.94

3.4 Qualitative Results

To inform the quantitative data and results included above, we also conducted interviews with 10 participants. These interviews were conducted via Zoom with the first author at a mutually agreed time with each student participant. Interview questions were designed to potentially investigate the factors that may influence students' writing grade: how do you feel about your writing skills, and what is easy/difficult?; when you find an aspect of writing to be hard, what do you do?; what resources have you found to be helpful and why?; and What resources could be enhanced or created to help you more?

One theme from the individual student interviews was about the challenges that students encounter through the writing process. Some students noted that they had difficulty in managing the process. As Bob shared, "it's creating a draft, reviewing and editing and then following that up with a final draft that has been difficult." Other students identified focusing and organizing while drafting text as a challenge. One student, Olivia, noted that, "I kind of struggle to organize my thoughts in a way that makes sense to other people like it just doesn't translate well between

my brain and into typing," while another student, Tarin, shared that, "trying to connect one paragraph to the other, with any flow, is not easy; it takes time to try to get a good transition." Karen commented about the distinct differences between lab reports' argumentative genre and need for specific content and terminology: "It's been a big transition, especially with chemistry; it just has so many calculations that you have to include, which has been difficult for me." Each genre of writing has its own style and types of content.

Adapting to the audience while writing their lab report was another challenge for some students. As Jennifer pointed out, "instead of just writing about it and being technical, I have to backtrack and worry about audience." Another student, Kirk, observed, "what audience I'm writing to? So how is that going to differ? Professional audience versus, uh, just general a public audience." This is an example where students reviewing a short video about the assignment and rubric could help them.

Another theme that surfaced in student interviews was the usefulness of in-person feedback. Students commented that they valued feedback from instructors, finding that it helped them learn and improve. Other students commented on seeking out peer feedback or going to the campus Writing Center for a consulting session. Diane did not feel peer editing was helpful: I have never found student reviews to be all that helpful; I feel like people are afraid of being too critical." Conversely, Kirk shared that, "it's nice to have an actual different set of eyes look at it," when using the Writing Center or asking for feedback from chemistry classmates. When discussing the usefulness of feedback from the Writing Center, two students suggested that it would be helpful to have one person at the Writing Center dedicated to science writing consultations.

A third theme that emerged from student interviews was the use of online tools and/or applications including information that helped them to develop new strategies for lab report writing. All interviewees shared that they have used Grammarly as a writing resource. Zotero, a reference management tool, was also mentioned as a resource, along with the Purdue OWL (an online writing lab administered through the Writing Center at Purdue University). Google scholar was identified by one student as a source for finding sources, and Kahn Academy was noted by another student as a helpful tool for finding example papers to emulate.

When asked about the webtools provided through Canvas as part of this research project, all students responded that they found the tools potentially useful. Kirk shared that he, "watched a number of the videos; they helped as well," while Olivia stated, "I think these are all excellent resources." Tom commented that he, "liked the provided videos and would absolutely view them to learn how to better manage writing assignments." A few of the students confided that they had not reviewed the materials before the interview, but they all said that they found them useful upon reviewing them during the Zoom discussion. Of note, three students shared that the materials were difficult to find within Canvas and suggested making them easier to access for students.

4 Discussion

Many students find writing tasks to be a challenge. This study explored students' perspectives about their writing skills and how webtools such as strategy videos, infographics, and high-quality examples could help them improve. Specifically, the research questions were: What were participants' perspectives about writing via an online survey and follow-up interviews? Did participants' pre/post writing content and quality improve with use of WRITE following students' difficulties having access to the webtools?

Due to the varied and complex nature of writing, many students can struggle when assigned academic writing assignments in new or less familiar disciplines and genres, particularly in STEM fields. Because genre knowledge is also tied to background knowledge (Bawarshi & Reiff, 2010), novice learners can also struggle with writing new contexts. This study looked to capture students' perspectives on their college-level writing experiences and to assess the usefulness of webtools to support their academic writing. To do so, we gathered feedback from student participants through surveys and follow-up interviews, as well as direct assessment of students' chemistry lab reports. While overall results suggest that certain priorly established behaviors can predict success and/or improvement, in-person feedback and supplemental webtools were also identified by students as meaningful supports that helped them improve. This supports research demonstrating the benefits of tutoring consultations (Learner, 2005), instructor feedback via conferencing, and digital technologies that support reading and writing skills (Turunem, 2019). As such, webtools can be designed to support students to engage these strategies and skill

development. Findings revealed that making such webtools easily accessible can go a long way in students' awareness and use of such tools.

The survey and interview data offered interesting insights into students' perspectives about writing. The Pearson correlations indicated that students' attaining a good grade in writing assignments are associated with: their ability to focus attention in class to understand the content; ease in attaining answers to their questions about the writing assignment; facility with spelling words and creating sentences; knowing what edits to make; attaining feedback from peers, instructors, or the writing center; and addressing their self-perceived difficulties in writing from their high school years. These correlations map closely to the survey results. The more these aspects of writing can be addressed by university instructors and campus services, the more successes students are likely to experience with writing assignments such as STEM lab reports. This reflects writing research (*e.g.*, Biagno & Salavory, 2021; Graham et al., 2020; Hyatt et al., 2017; Mastropieri & Scruggs, 2018) showing that practicing writing skills and offering strategy ideas helps students manage planning, composing, and editing text.

Providing further insight into survey results, the qualitative interview data resulted in similar comments from students. Interviews revealed that students perceive multiple challenges when completing academic writing assignments, from getting started and organizing thoughts to adapting to their audiences. This maps to the findings from other writing researchers (*e.g.*, Graham & Alves, 2021; Graham & Harris, 2017) who have helped to document the struggles of students who find writing to be difficult. Participants in this study also shared that they value in-person feedback and use it to improve drafts and/or future writing assignments. Students further commented on how in-person feedback helps them with writing and online tools or applications. Students also use and appreciate online resources. Their overall review of the STEM webtools available to support their chem lab report writing during this intervention was positive. Lastly, some students shared in interviews that they had difficulty finding the webtools within their Canvas site, and they suggested that the resource be made more accessible in future iterations. Research focused on teaching writing online also identifies accessibility as an important factor to support student use in online resources (Warnock, 2015; Hewett et al., 2021).

5 Limitations and Future Research

Analysis of writing artifacts, experiences, and perspectives is always challenging given that the influences of students' prior and concurrent writing contexts and experiences can never be fully explained or assessed (Hendricks, 2018). Furthermore, writing is a complex task that entails many genres. Expository texts such as lab reports is one example. It is likely also one of the most challenging genres because of its technical and less frequent use by students. Narrative texts, for example, are much more common and may render different and higher scores of students' writing. This study's findings are not representative of all the students could be capable of in writing.

While instructors introduced web tools in class during week 8 and re-mentioned in later classes, there was no available system to track students' use of the webtools (*e.g.*, which students accessed one or more, and did any students return to review any?). We know that the participants had access to the webtools and were offered a discussion of what they were, attributing their change in writing skills by the end of the study is a lingering question. Due to technical limitations within the Canvas platform, we had no mechanism to track how often, or long students interacted with the webtools provided. The webtools were a part of their knowledge base for managing writing, but the extent of that development and use is unknown. In a future study, researchers could create a dedicated tab within the course website to have more prominent navigation links or integrate a tracking system to monitor webtool usage such as is available with Google Analytics.

The results of this study could have had a potential impact of unmeasured variables such as students' prior exposure to webtools or writing strategies. With writing being a core task of STEM undergraduate students, they have the option to seek help from a campus writing center, classmates, online webtools and browser apps such as Grammarly and more recently, Artificial Intelligence (AI) such as ChatGPT. Students' demographics (*e.g.*, being low-versus high-income, English Learner) could add to the confounding extent of these unmeasured variable in this study.

Additional limitations of this study include the sample size and the self-selection of participants who volunteered for the project. Due to the sample size, results cannot be generalized. Student backgrounds and various learning environments were also uncontrolled variables. Look-

ing forward, a future study could try to increase the number of student participants for a larger sample size. Future studies could also include more genres of writing and compare students' pre/post content and quality scores. There may be differences between narrative and expository types of texts. A weblink tracking system could help count the number of times each participant used a webtool link and how many times they returned for review, if any.

6 Conclusion

Writing is a challenging task for many people. This is even more true of a genre such as lab reports which is not a typical type of narrative employed in daily life. This study illustrates the benefits of students having access to on-demand strategy ideas via short web videos and infographics to help them plan, organize, draft, edit and complete better-quality texts than they may have otherwise produced. This focus addresses an important need as many students, including some in this study, expressed their having challenges with writing for many years and thus, not feeling motivated to spend much time on drafting and edits drafts of assignments before submission. In the minds of some students, why should they spend more time on a task when I have not had success in the past? The results of this study highlight that students can improve with access to web tools for writing. Changing a negative mindset to a positive one is valuable, which this study helps to illustrate.

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Conflicts of Interest

The authors declare that they have no conflict of interest.

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